

# **- Evaluation of Performance of THOR Mod Kit in Vehicle Crash Tests -**

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JAMA / JARI

THOR User's Meeting

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# Overall Progress of THOR Mod Kit Tests by JARI/JAMA/JAPIA

## 1. Certification Tests

- Thorax
- Abdomen
- Head
- Face
- Knee

## 2. Sled Tests

- Difference of seating procedure
- Difference of D-ring location
- Difference of seatbelt load limiter
- Deployment and non-deployment of airbag

## 3. Vehicle Crash Tests

- 55 km/h full width rigid barrier test
- 64 km/h offset deformable barrier test

## 4. Pre Braking Tests

JARI : Japan Automotive Research Institute

JAMA : Japan Automotive Manufacturers Association

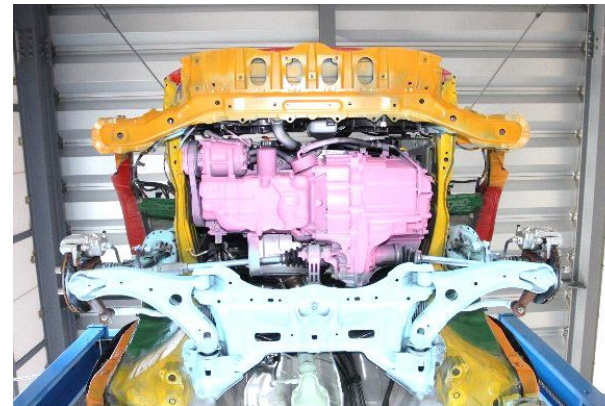
JAPIA : Japan Auto Parts Industries Association

# 1. Objective

To evaluate a performance of the THOR Mod Kit in two full crash tests using a mini **passenger car**.

- By testing a mini passenger car as the representative of Japanese cars in two high speed frontal crash test of JNCAP(55 km/h FWRB, 64 km/h ODB), we will be able to compare response, measurement capability and durability between the THOR Mod Kit and the Hybrid III.
- These data will help us obtain the important basic data for future introduction of THOR to Japan.

## 2. Test Vehicle

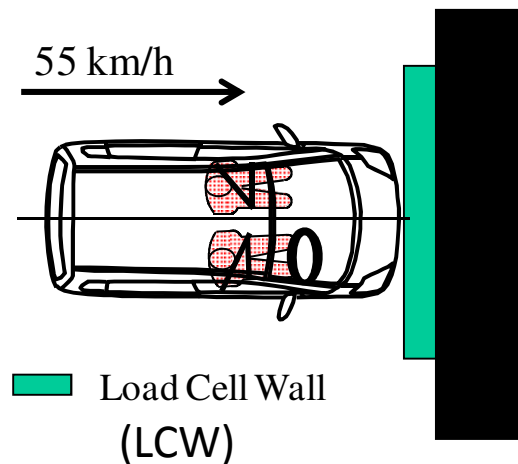


2013 Honda Fit

# 3. Test Conditions

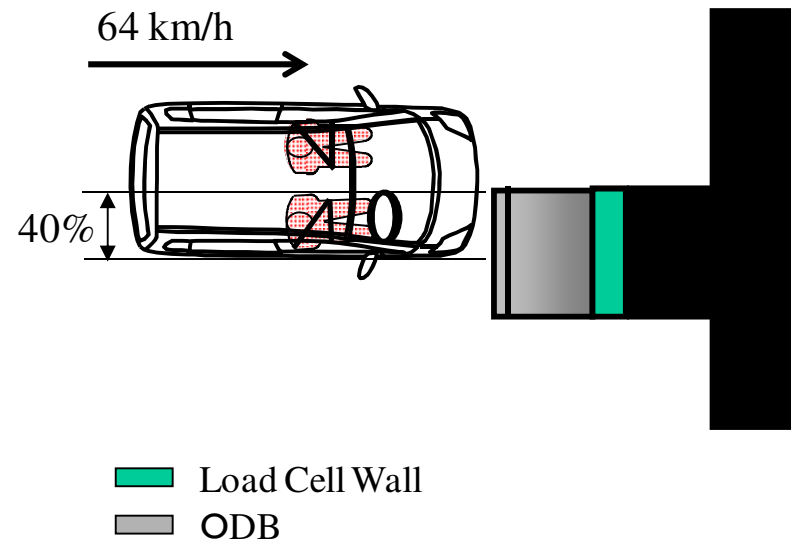
## FWRB (Full Width Rigid Barrier)

Test Vehicle: Honda Fit  
Impact Speed: 55 km/h  
Height of LCW: 80 mm  
Dummy: DR; THOR Mod Kit  
FP; Hybrid III  
(as a weight ballast)  
Test Weight: 1226 kg



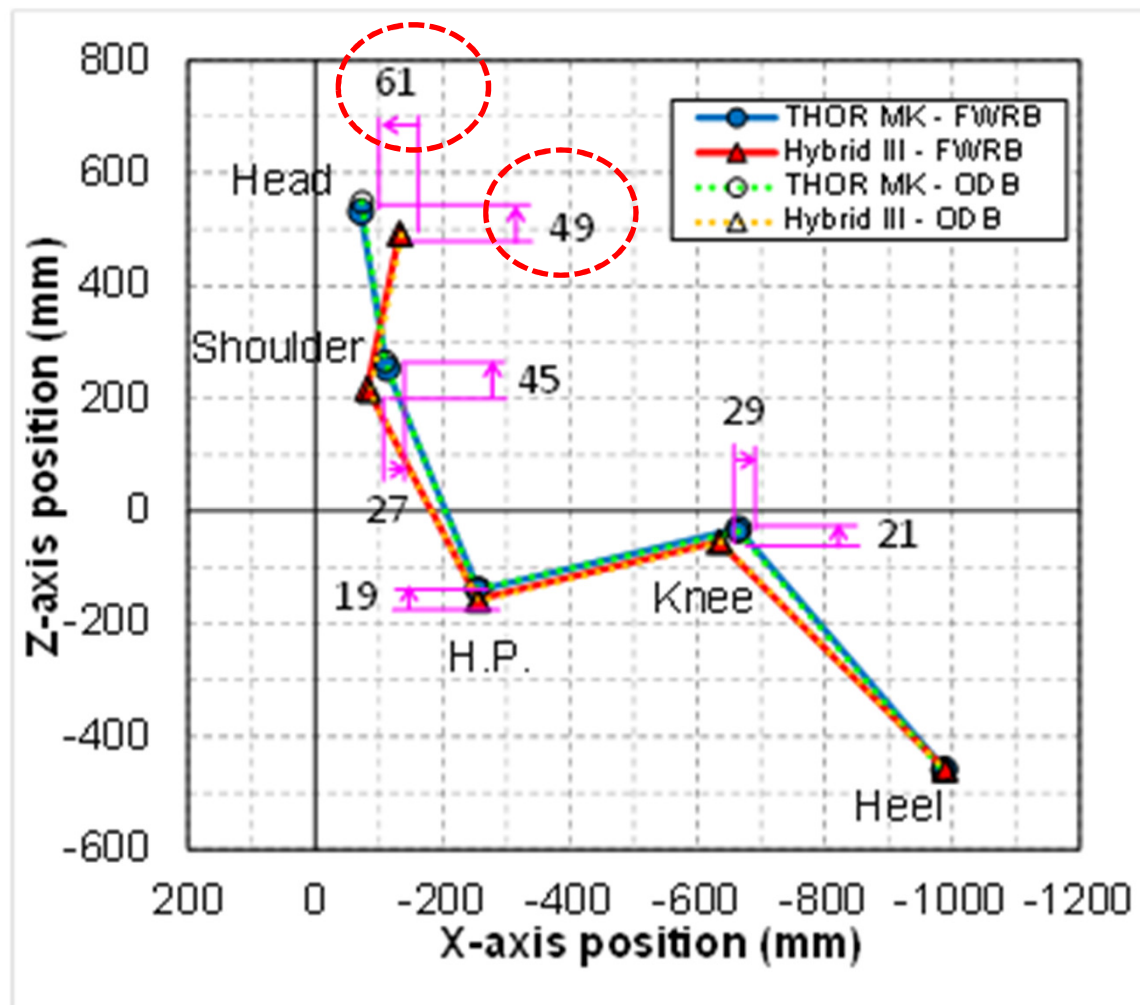
## ODB (Offset Deformable Barrier)

Test Vehicle: Honda Fit  
Impact Speed: 64 km/h  
Height of Honeycomb: 200 mm  
Dummy: DR; THOR Mod Kit  
FP; Hybrid III  
(as a weight ballast)  
Test Weight: 1221 kg





# 4. Dummy Positioning



Hybrid III measurements are from JNCAP tests.

THOR Mod Kit



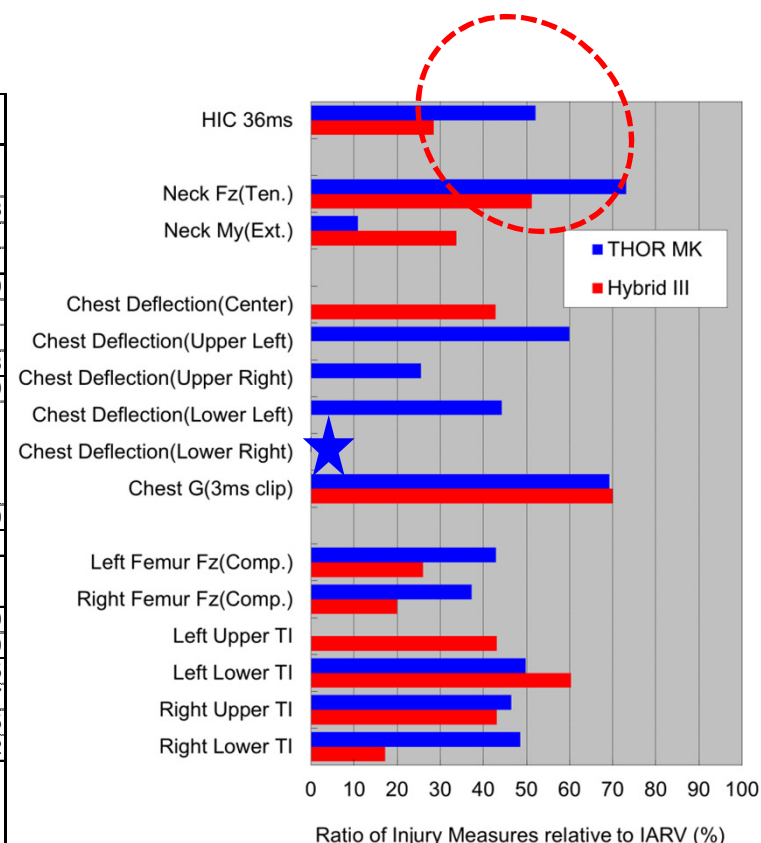
Hybrid-III



# 5. Dummy Injury (THOR vs Hybrid III)

## FWRB

		IARV	Ref	THOR Mod Kit	Hybrid III
Head	BRIC(Previous Version)	1	1	0.54	No sensor
	BrIC(Latest Version)	TBD	2	0.52	
	HIC 36ms	1000	3	520.8	
	HIC 15ms	700	1	376.4	
	3ms clip (G)	80	1	59.7	
Upper Neck	Tension Force (N)	2520	1	1842.1	1290
	Compression Force (N)	3600	1	234.9	-
	Flexion at OC (Nm)	48	1	1.5	-
	Extension at OC (Nm)	72	1	7.8	24.3
Chest	Deflection(Center)	63	4	No sensor	27.0
	Deflection(Upper Left) (mm)			37.7	No sensor
	Deflection(Upper Right) (mm)			16.1	
	Deflection(Lower Left) (mm)			27.9	
	Deflection(Lower Right) (mm)			-9.5	
	3ms clip (G)	60	1	41.5	42.0
Abdomen	Deflection (mm)	111	1	69.6	No sensor
Acetabulum	Left Resultant Force (N)	3500	1	1486	No sensor
	Right Resultant Force (N)			1042	
Femur	Left Femur Force (N)	10000	1	4288	2600
	Right Femur Force (N)			3725	2000
Tibia	Left Upper Tibia Index	1.16	1	Sensor N.G.	0.5
	Left Lower Tibia Index			0.58	0.7
	Right Upper Tibia Index			0.54	0.5
	Right Lower Tibia Index			0.56	0.2
Ankle	Left Inversion/Eversion (deg)	35/35	1	26.6	No sensor
	Left Dorsiflexion/Plantarflexion (deg)			16.1	
	Right Inversion/Eversion (deg)			37.4	
	Right Dorsiflexion/Plantarflexion (deg)			14.8	



### Note

Currently all IARVs are preliminary. Reference are as followed;

Reference 1: Saunders, et al. "NHTSA'S TEST PROCEDURE EVALUATIONS FOR SMALL OVERLAP/OBLIQUE CRASHES" the 22nd ESV Paper No. 11-0343, 2011

Reference 2: E.Takhounts. et.al "Development of Brain Injury Criteria (BrIC)" STAPP CAR CRASH JOURNAL#57;243-266p, 2013

Reference 3: UN/ECE R94

Reference 4: FMVSS208

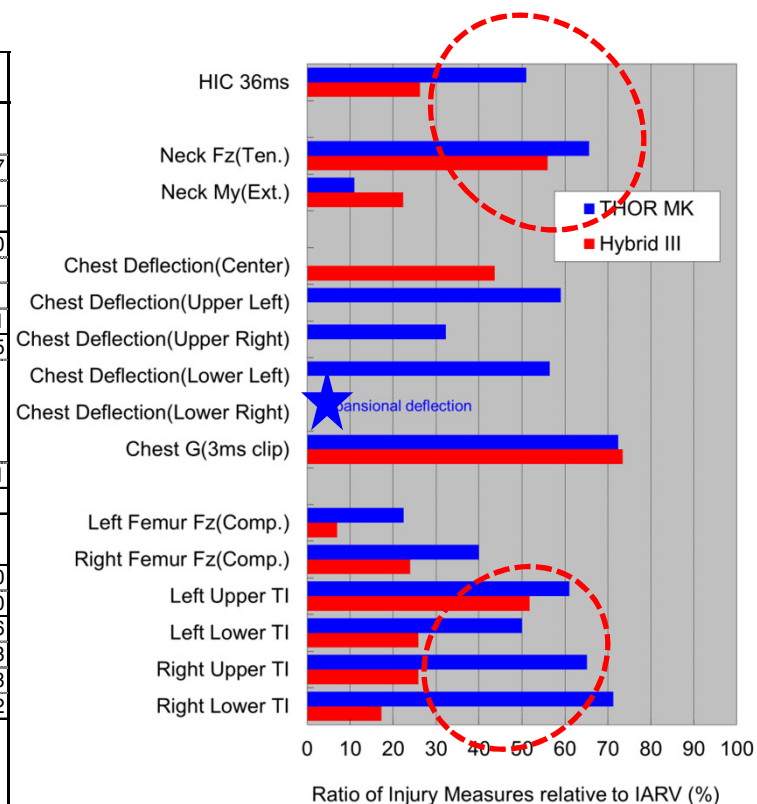
Negative value in chest deflection means chest expansion

Hybrid III measurements are from JNCAP tests.

# 5. Dummy Injury (THOR vs Hybrid III)

## ODB

		IARV	Ref	THOR Mod Kit	Hybrid III
Head	BRIC(Previous Version)	1	1	0.60	No sensor
	BrIC(Latest Version)	TBD	2	0.74	
	HIC 36ms	1000	3	510.1	
	HIC 15ms	700	1	291.5	
	3ms clip (G)	80	1	53.0	
Upper Neck	Tension Force (N)	2520	1	1653.5	1410
	Compression Force (N)	3600	1	803.3	-
	Flexion at OC (Nm)	48	1	1.6	-
	Extension at OC (Nm)	72	1	7.9	16.1
Chest	Deflection(Center)	63	4	No sensor	27.5
	Deflection(Upper Left) (mm)			37.2	No sensor
	Deflection(Upper Right) (mm)			20.3	
	Deflection(Lower Left) (mm)			35.5	
	Deflection(Lower Right) (mm)			-17.8	
	3ms clip (G)	60	1	43.4	44.1
Abdomen	Deflection (mm)	111	1	68.7	No sensor
Acetabulum	Left Resultant Force (N)	3500	1	1121	No sensor
	Right Resultant Force (N)			1485	
Femur	Left Femur Force (N)	10000	1	2247	700
	Right Femur Force (N)			3995	2400
Tibia	Left Upper Tibia Index	1.16	1	0.71	0.6
	Left Lower Tibia Index			0.58	0.3
	Right Upper Tibia Index			0.76	0.3
	Right Lower Tibia Index			0.83	0.2
Ankle	Left Inversion/Eversion (deg)	35/35	1	33.5	No sensor
	Left Dorsiflexion/Plantarflexion (deg)			23.2	
	Right Inversion/Eversion (deg)			37.2	
	Right Dorsiflexion/Plantarflexion (deg)			21.5	



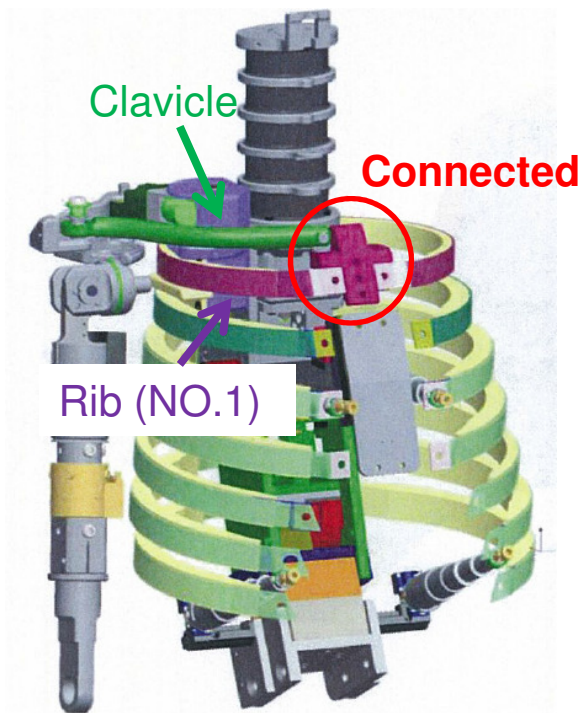
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 Negative value in chest deflection means chest expansion  
 Hybrid III measurements are from JNCAP tests.



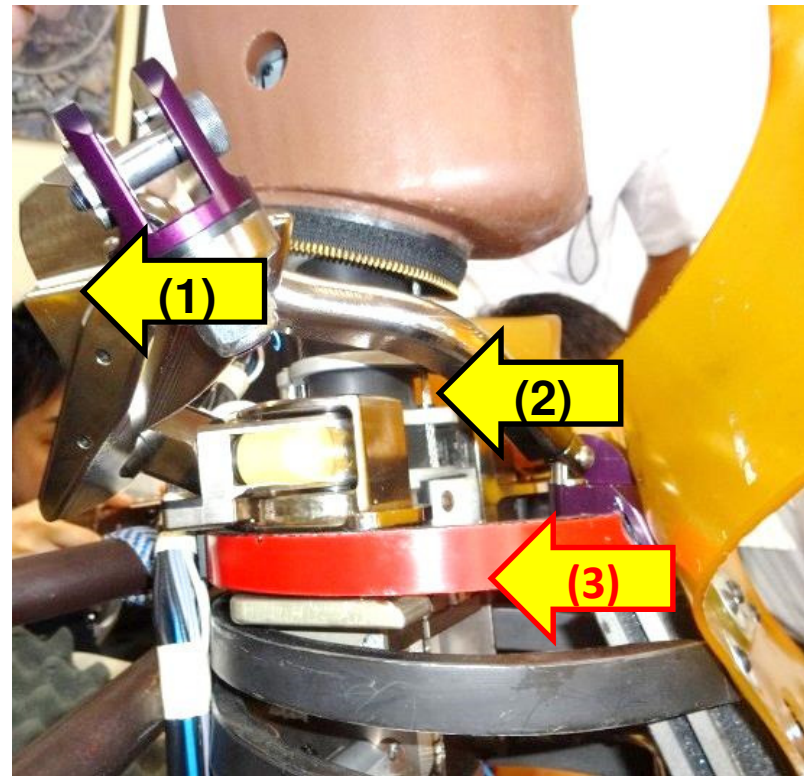
## 6. Discussion

### (1) SD-3 Shoulder Design

Even without external force to the ribs, rib deflection increased due to shoulder movement. This movement may be biofidelic, however, we would like to see a quantitative correlation between THOR and PMHS with respect to the increase of rib deflection due to shoulder movement.



Clavicle and Rib (NO.1) are connected

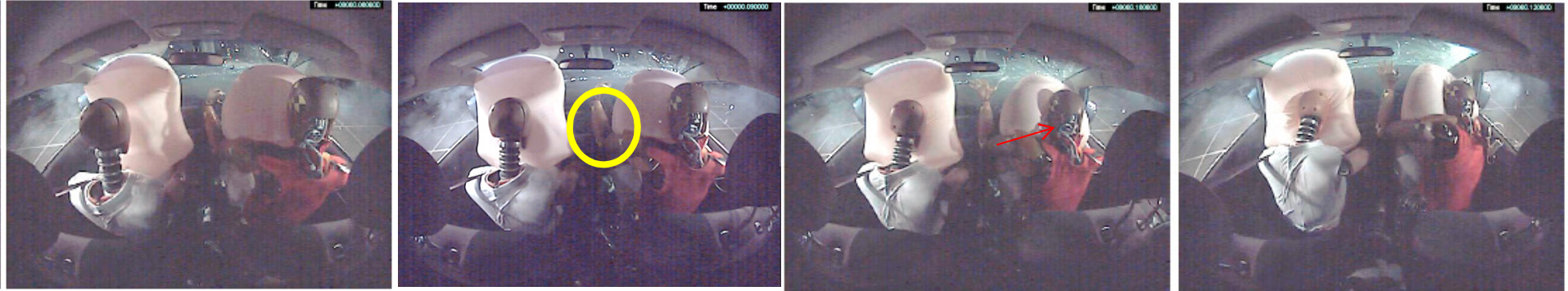


- (1) Shoulder move rearward
- ⇒(2) Clavicle move rearward
- ⇒(3) **Rib deflection increases**

# 6. Discussion

## (2) Dummy Kinematics

ODB64km/h



80 ms

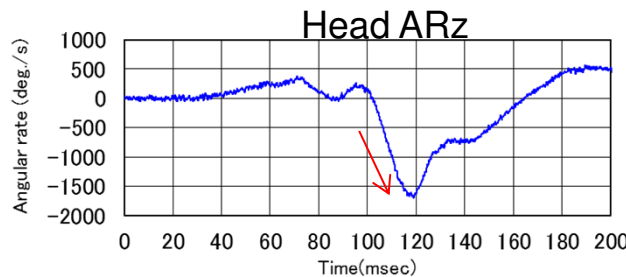
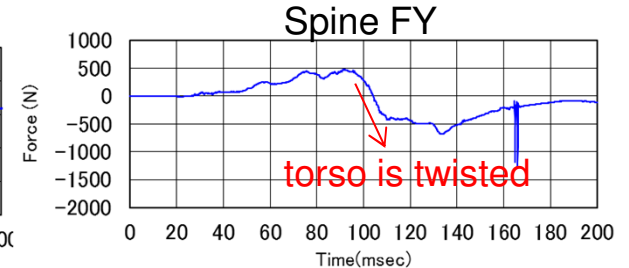
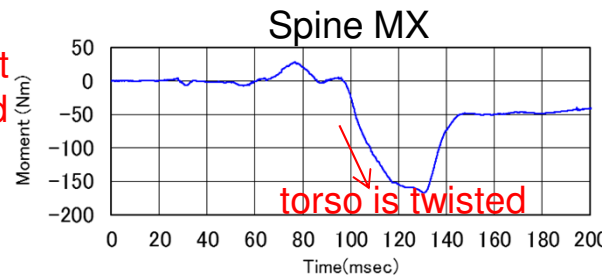
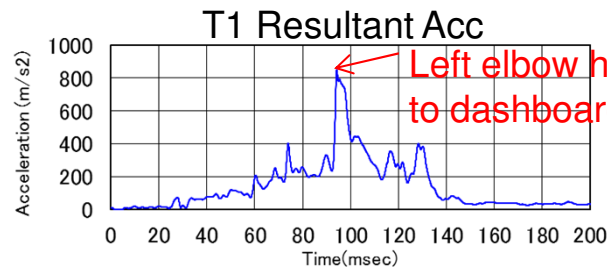
90ms

100 ms

120 ms

Left elbow hit to dashboard Left shoulder is pushed to rearward and upward

Right shoulder (belted side) move forward and torso is twisted

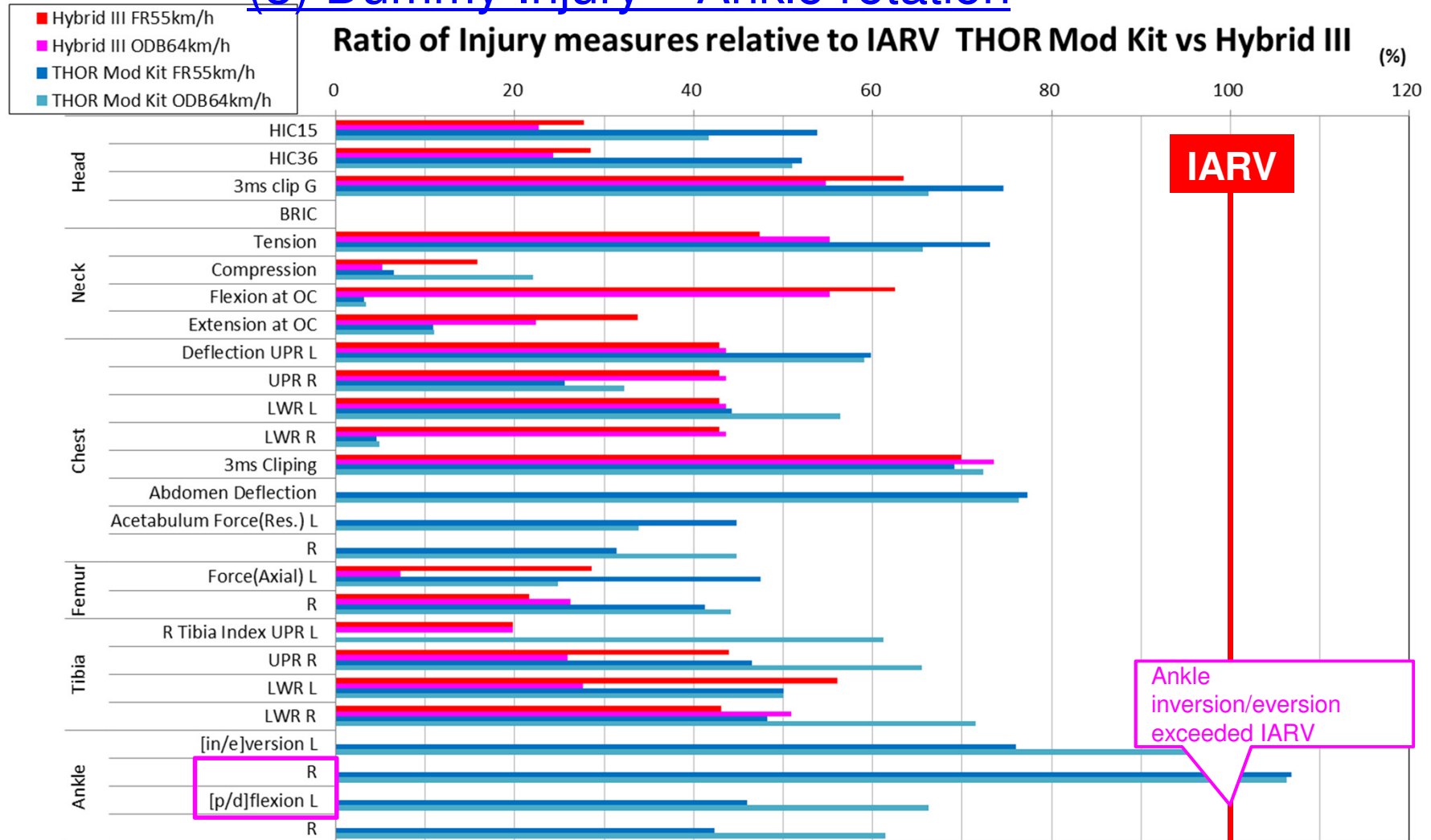


Torso twist affects Head ARz (BrIC)

- Left elbow to dashboard contact causes the torso twist.
- It is necessary to verify whether this dummy kinematics is similar to PMHS<sub>10</sub>

# 6. Discussion

## (3) Dummy Injury – Ankle rotation

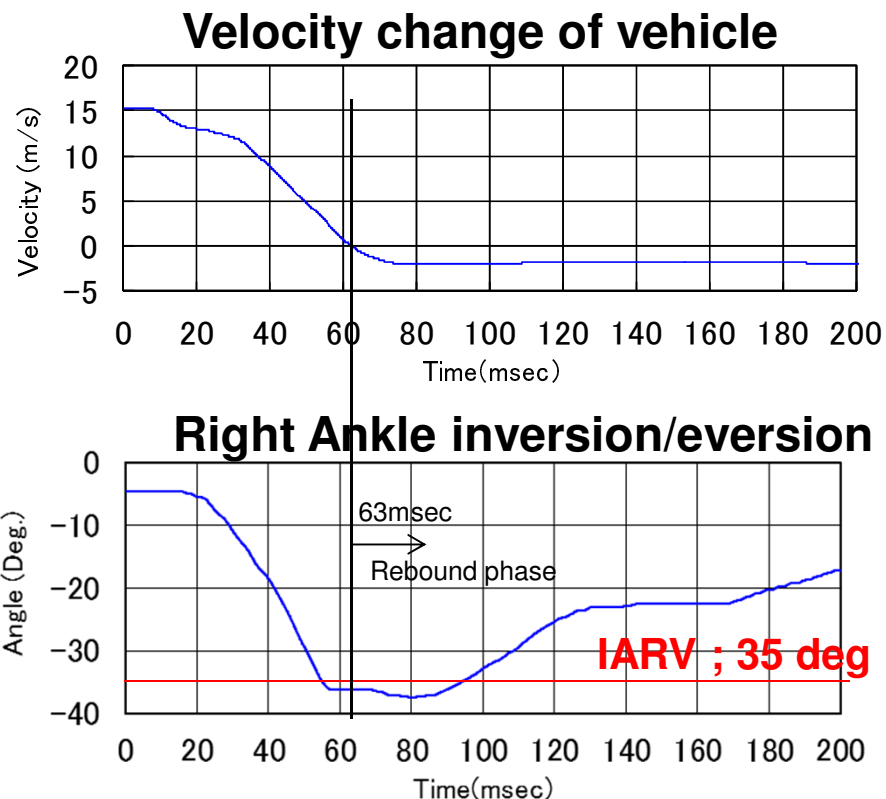
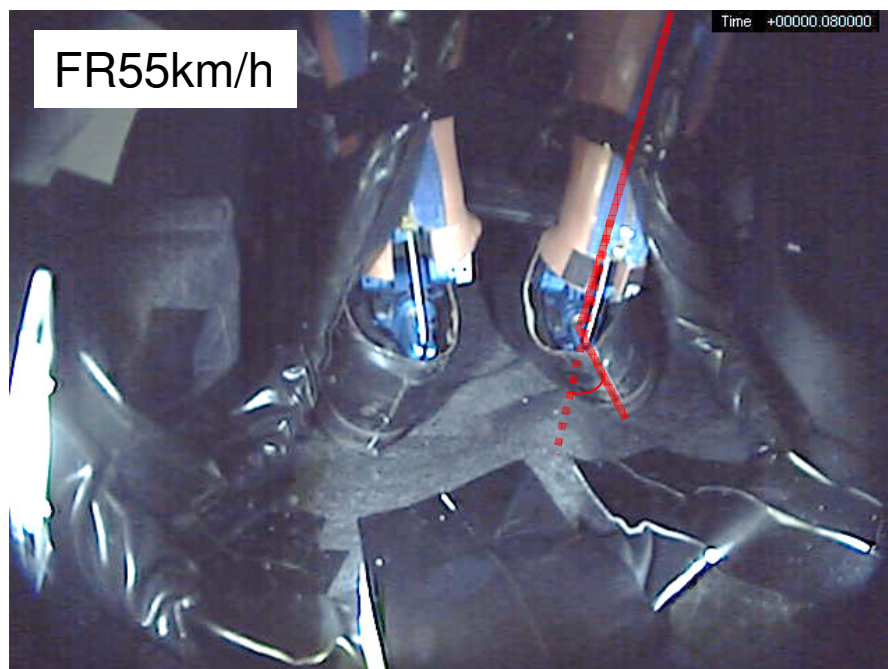


**Ankle inversion/eversion exceeded IARV**



# 6. Discussion

## (3) FWRB - Ankle Inversion/Eversion



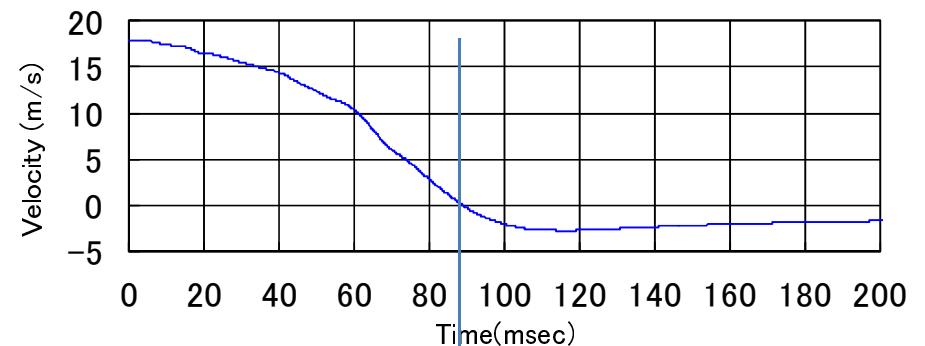
- Eversion is maximum at vehicle rebound phase.
- Decreasing structural intrusion may not solve max inversion/eversion

# 6. Discussion

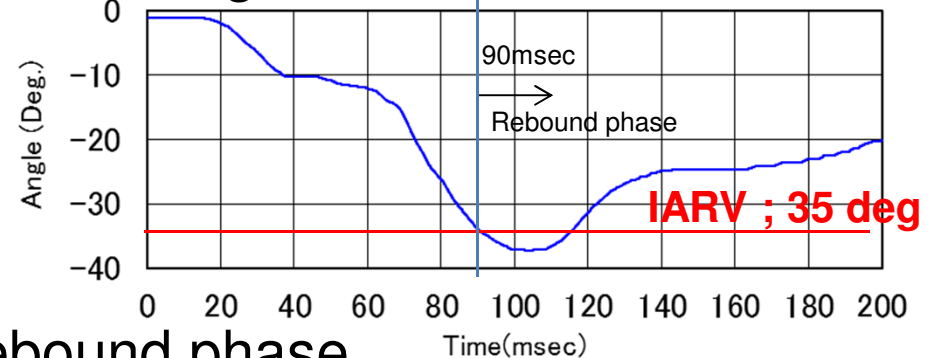
## (3) ODB - Ankle Inversion/Eversion



Velocity change of vehicle



Right Ankle inversion/eversion



- Eversion is maximum at vehicle rebound phase.
- Decreasing structural intrusion may not solve max inversion/eversion

**It is difficult to identify root causes and countermeasures for ankle inversion / eversion under the current test condition.**



## 7. Summary

### THOR durability

There is no durability issue found in two tests.

⇒ JNCAP assessment is suitable (but need more tests)

### SD-3 shoulder design

Even without external force to ribs, rib deflection increased due to shoulder movement.

⇒ Would like to see a quantitative correlation between the THOR dummy and PMHS

### Dummy kinematics

Left elbow contact to dashboard causes higher head ARz.

⇒ We would like to see whether this dummy kinematics is similar, compared to the PMHS.

### Ankle Rotation

Ankle eversion exceeded IARV at vehicle rebound phase.

⇒ It is difficult to identify root causes and countermeasures for ankle inversion / eversion under the current test condition.